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Mathematical Modelling and Simulation of Protein Denaturation during Heat Treatment of Dairy Fluids

FRG0217-TK-1/2010

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Synopsis

Fouling has been a problem since the invention of heat exchanger. The presence of such deposits on heater surface can reduce the efficiency of the heater, which leads to plant shut down and subsequently loss of production. Fouling in the dairy industry is the most severe as daily cleaning of heat exchangers is often required, compared to other industries which only need yearly cleaning. Dairy fouling is caused by the thermal denaturation of beta-lactoglobulin at temperatures above 70°C. Therefore, this work was carried out to help the understanding of how transport phenomena in a heater affects the protein denaturation process. Modelling of the concentration of the native protein, denatured protein and aggregated protein during heat treatment of dairy product was successfully performed using finite element computational method. Based on the simulated concentration profiles, it is clear that native protein is not the contributor to fouling. It was also found that aggregated protein solely cannot be the main foulant. However, there is also possibility where deposition is caused by both denature and aggregated proteins, but it is more complicated to predict the deposition pattern unless the ratio of the two depositing proteins involved is known through experiment. Experiments were also carried out to validate the simulation work, however, due to the raw materials used, results were found to be inconsistence.

Sinopsis

'Fouling' telah menjadi masalah sejak penciptaan penukar haba. Kehadiran deposit di permukaan pemanas boleh mengurangkan kecekapan pemanas, yang membawa kepada penutupan plant dan seterusnya kehilangan pengeluaran. 'Fouling' dalam industri tenusu adalah yang paling teruk kerana pembersihan harian penukar haba sering diperlukan, berbanding dengan industri-industri lain yang hanya memerlukan pembersihan tahunan. 'Fouling' tenusu disebabkan oleh penyahaslian haba beta-lactoglobulin pada suhu melebihi

70°C. Oleh itu, kerja ini telah dijalankan untuk membantu memahami bagaimana fenomena pengangkutan dalam pemanas mempengaruhi proses penyahaslian protein. Permodelan kepekatan protein asli, protein 'denatured' dan protein agregat semasa rawatan haba produk tenusu telah berjaya dilakukan dengan menggunakan kaedah numerik pengkomputeran. Berdasarkan profil kepekatan simulasi, jelas bahawa protein native bukan penyumbang kepada 'fouling'. Ia juga mendapati bahawa protein agregat semata-mata tidak boleh menjadi penyumbang utama. Walau bagaimanapun, terdapat juga kemungkinan di mana pemendapan adalah disebabkan oleh kedua-dua protein denatured dan protein agregat, tetapi ia adalah lebih rumit untuk meramalkan corak pemendapan kecuali nisbah pemendapan protein terlibat dikenali melalui eksperimen. Eksperimen juga dilakukan untuk mengesahkan kerja simulasi, bagaimanapun, disebabkan oleh bahan-bahan mentah yang digunakan, keputusan didapati tidak konsisten dan tiada rumusan dapat diberikan.